MIT ACOUSTIC UNCERTAINTY PROJECT

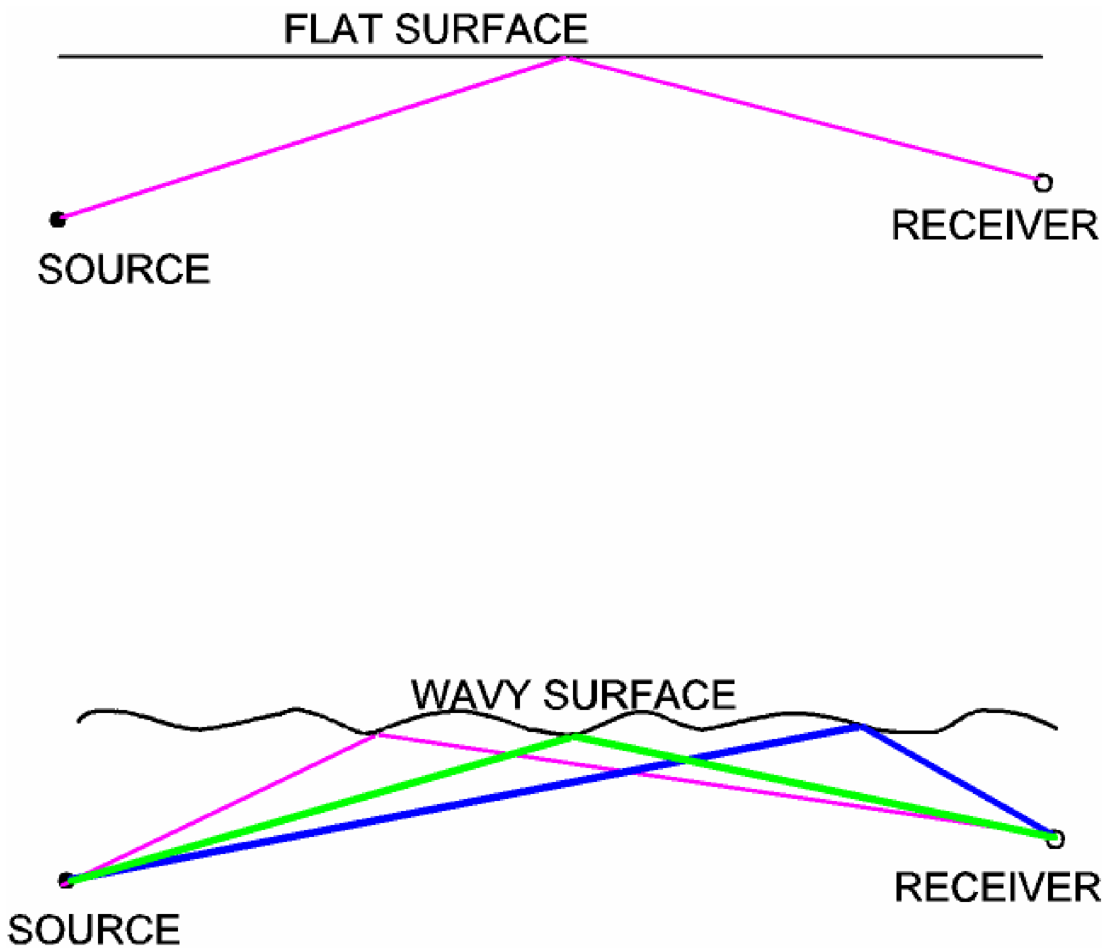
Details and Influence of Surface Morphology

By: Jerome H. Milgram

Is it Important?

Possible Explanations for Amplifications of Sound at Receiver for some Positions

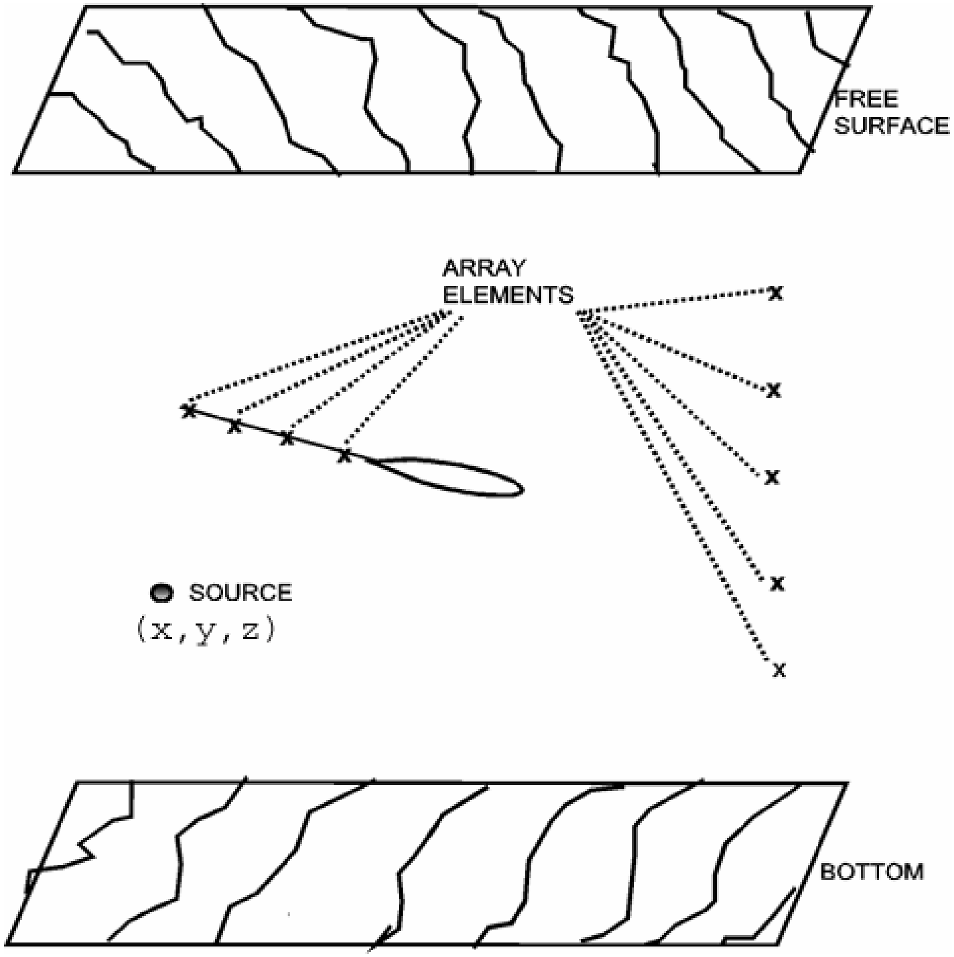
There may be more specular reflection points



Is The Surface Morphology Important?

- Qualitative examination indicates it is probably important.
- To help answer the question quantitatively we will consider the effect of sample functions of the free surface elevations.
- First we have to make the sample functions from the known statistics of the free surface elevation which is a random process.
- We will start with a common approximation with plans to be more accurate in the future.

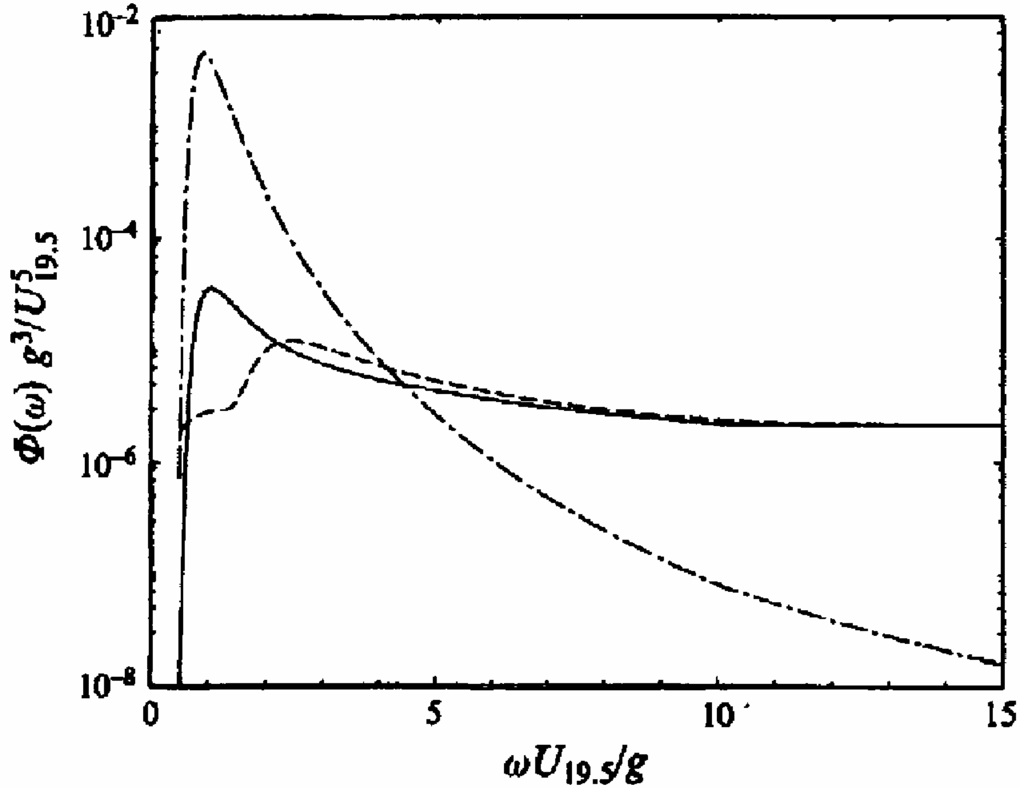
The Geometry



Surface Elevation Sample Functions

Surface elevation a nonlinear process: $\varsigma = \varsigma_1 + \varsigma_2 + \varsigma_3 + \ldots$

ς_2 and ς_3 are functions of ς_1.



--·--·-- Bjerkass-Riedel Spectrum (Φ_{11}), —— (Φ_{13}) (values are negative),

- - - - - (Φ_{22})

A Gaussian Sample Function has the same statistics as ς_1 or has

Statistics which approximate ς.

The State of the Art in Wave Simulation

- Measured Wave Spectra (2D and 3D) include linear and nonlinear wave components.

- The linear wave components represent a Gaussian random process; the nonlinear components do not.

- Methods to determine the nonlinear wave components from measured spectra in 3D do not exist, and their proper simulation may be more important for 3D waves. – **research is needed.**

- We know how simulate 2D and 3D sample functions of the part of the wave field from the linear wave part of the wave Spectrum (directional for 3D) ➔ Gaussian process.

- We know how to simulate the nonlinear part of the wave field from the linear wave part of the spectrum in 2D, but this is not commonly used in wave simulation because of the computational burden and the effect is relatively small for the large waves.

- Because of the above, and unknown parts of the problem in 3D, the usual approximation is to treat the total spectrum as associated with a Gaussian random process, either for 2D or 3D.

- The 3D waves in a sample function are then a sum of independent sinusoidal components of varying direction and frequency (or wave number).

Generation of Sample Functions of 3D Surface Waves for a Gaussian Process

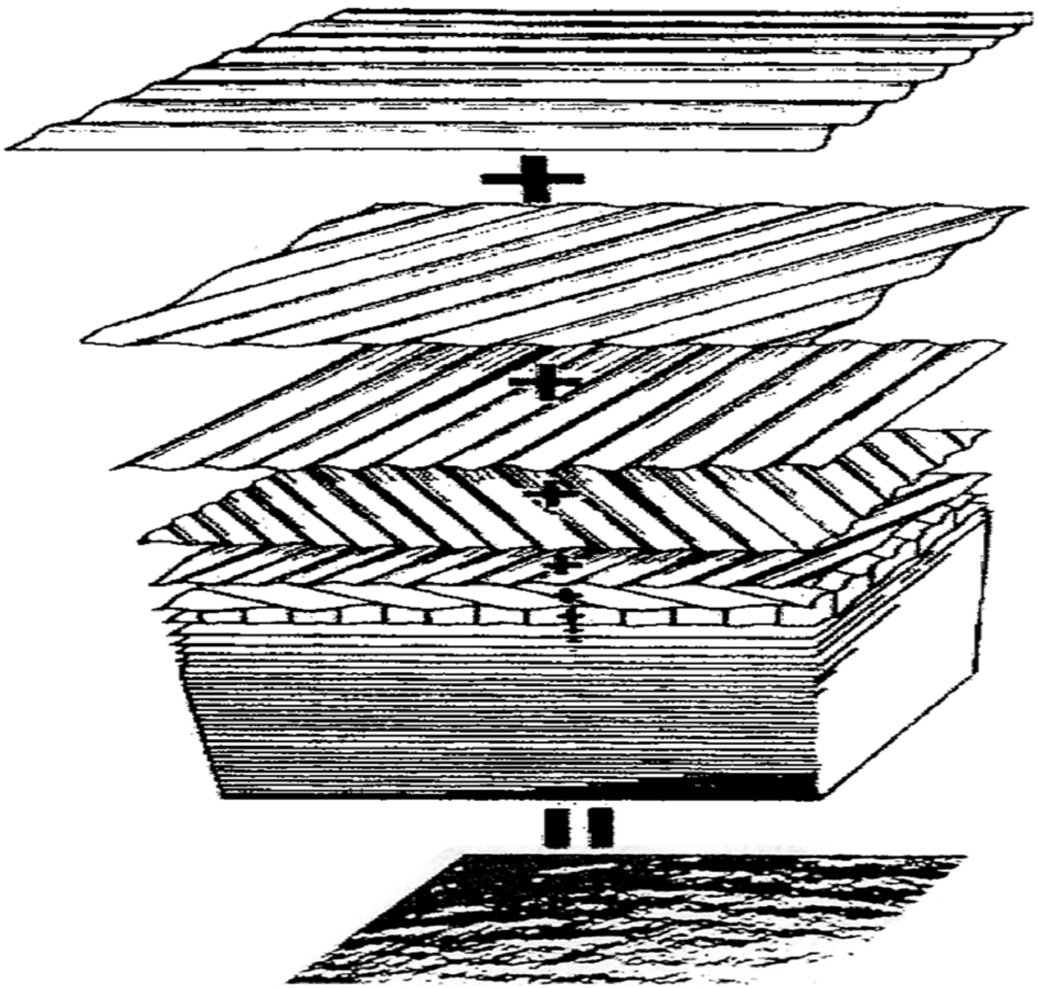
- The “conventional” approach is to take advantage of the computing speed of 2D FFT’s [$\varsigma = \varsigma(x,y)$].

- An 8192 x 8192 point FFT, with the ~64 million coefficients computed from the spectrum and a random number generator can simulate a patch of 819 meters x 819 meters with 0.1 meter spacing of the points in 25 minutes on a 1 GHZ processor.

- We have used a DSP (fitting inside a PC) which does this in about 2 minutes.

- For much larger surface dimensions and closer point spacings, with many samples simulated, the computing time becomes such burden that it needs more attention.

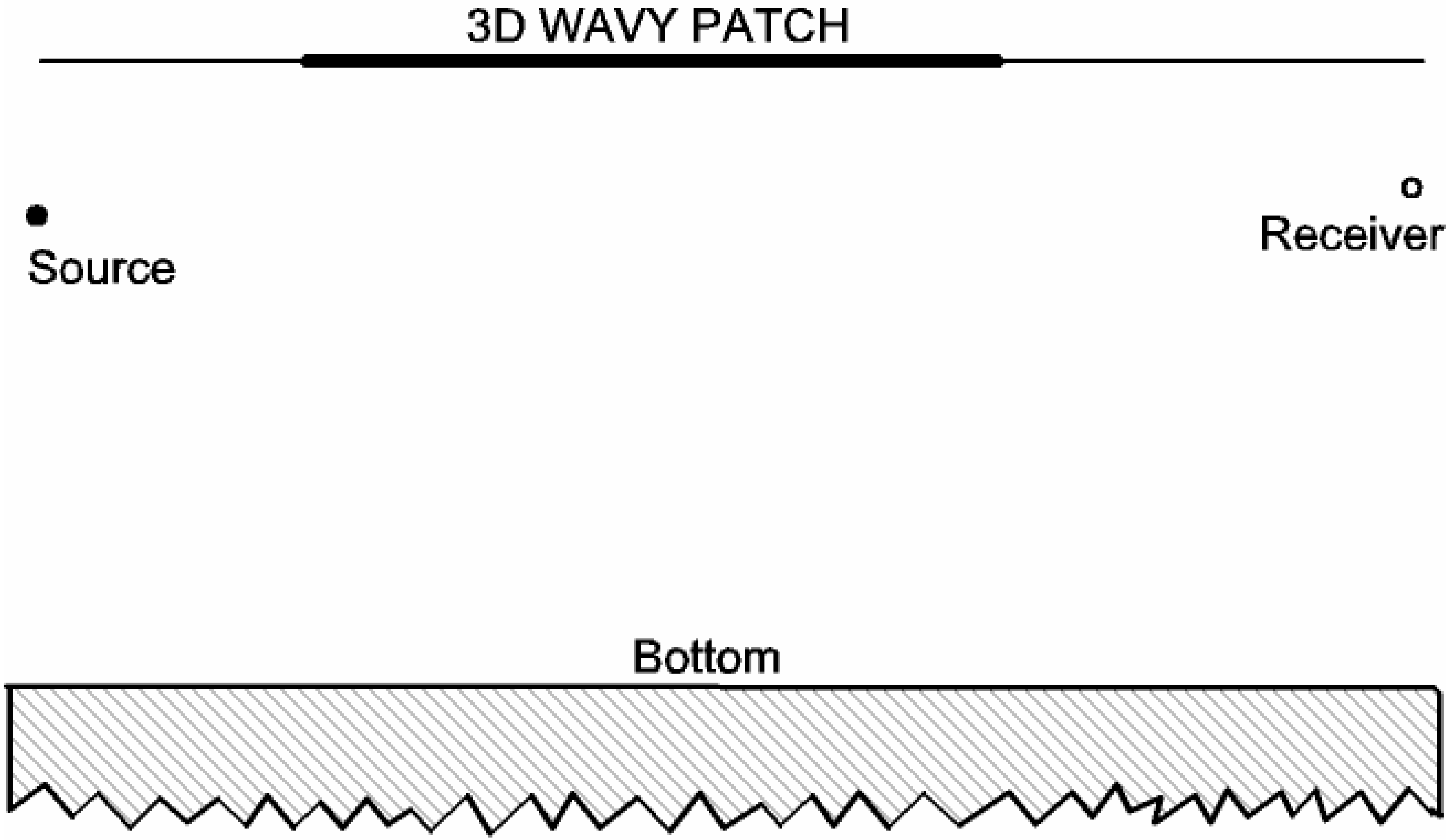
HIGH RESOLUTION 2D WAVES AT A FEW ANGLES



For 8000 Wavenumbers and 180 angles, computing time on a 1 GHZ Machine is 36 seconds. (1 degree angular resolution).

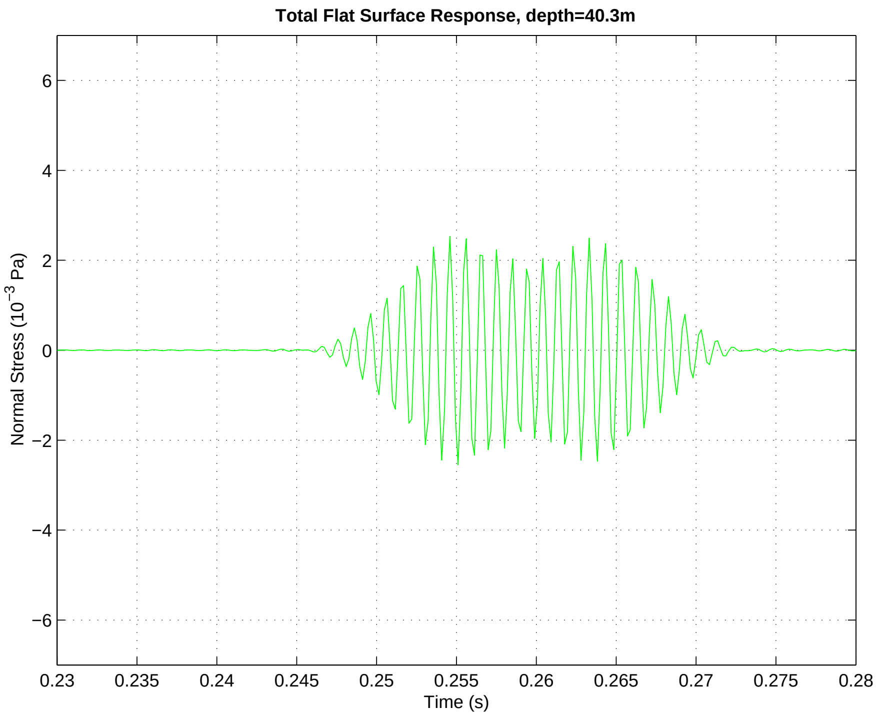
GEOMETRY FOR COMPUTATIONS

Wind Speed = 15 m/s and Pierson-Moskowitz spectrum with $\cos^4$ spreading function



•

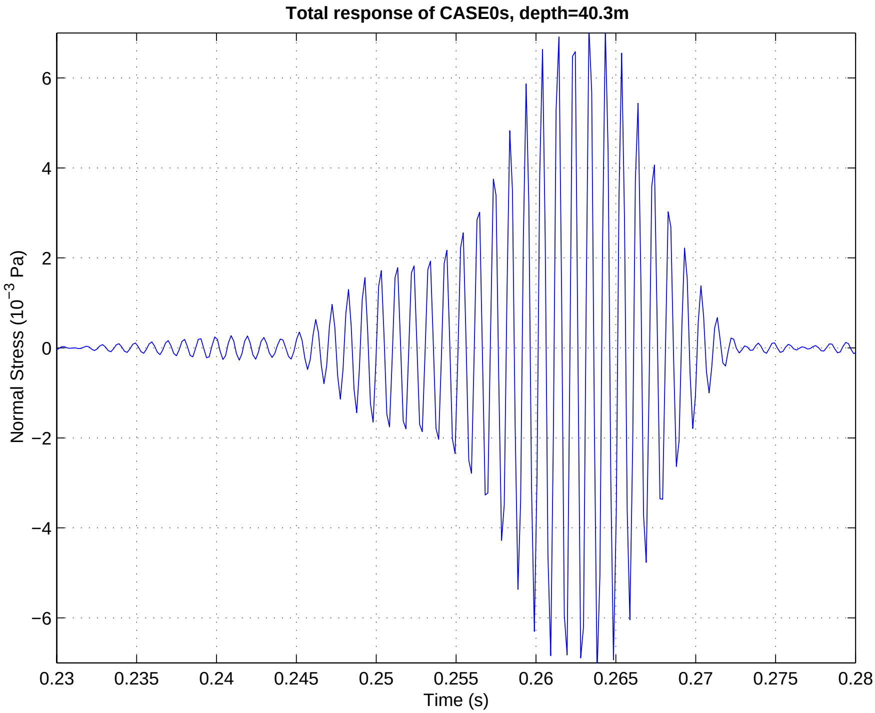
FLAT SURFACE



TIME

SOUND PRESSURE AT THE RECEIVER

3D WAVY SURFACE



TIME

Future Activities

- Optimize OASES/SCATT computer programs for fast computing with a large surface patch with irregular shapes evolving in time. Possibly program a DSP for the task. Check energy conservation.

- Develop measured wave decompositions into linear and nonlinear components in 3D.

- Develop 3D surface wave simulation methods for nonlinear components if necessary.

- Perform computations on several spectral models: Pierson Moskowitz, Jonswap, Pierson Stacy, Bjerkass-Riedel; with several direction spreading models and determine influence of wave model on computed source location and classification estimates.

- Compare full spectrum simulation results with fast computation results having limited angular resolution.

- Develop hardware and software to measure estimates of surface wave directional spectra from an upward-looking 4-beam ADCP on an AUV.

A NEED IN RAPID ACOUSTIC ENVIRONMENTAL ASSESSMENT

- Develop a means to estimate the directional wave spectrum in “almost” real time with an ADCP on an AUV.